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stant jaring of the building by the shutting of the doors belonging to it.

I am, Sir, with great esteem,
your friend and humble servant,
ANDREW ELLICOTT.

Mr. Robert Patterson, }
V. P. of the A. P. S. }

No. XXIV.

Observations and Experiments relating to equivocal, or spontaneous, Generation. By J. Priestley, L. L. D. F. R. S.

Read, Nov. 18th, 1803.

THERE is nothing in modern philosophy that appears to me so extraordinary, as the revival of what has long been considered as the exploded doctrine of *equivocal*, or, as Dr. Darwin calls it, *spontaneous generation**; by which is meant the production of organized bodies from substances that have no organization, as plants and animals from no pre-existing germs of the same kinds, plants without seeds, and animals without sexual intercourse.

The germ of an organized body, the seed of a plant, or the embryo of an animal, in its first discoverable state, is now

* Thus the tall oak, the giant of the wood,
Which bears Britannia's thunders on the flood;
The whale, unmeasured monster of the main,
The lordly lion, monarch of the plain,
The eagle soaring in the realms of air,
Whose eye undazzled drinks the solar glare,
Imperious man, who rules the bestial crowd,
Of language, reason, and reflection proud,
With brow erect who scorns this earthly sod,
And styles himself the image of his God;
Arose from rudiments of form and sense,
An embriion point, or microscopic ens !!!
Temple of Nature.

found to be the future plant or animal in miniature, containing every thing essential to it when full grown, only requiring to have the several organs enlarged, and the interstices filled with extraneous nutritious matter. When the external form undergoes the greatest change, as from an aquatic insect to a flying gnat, a caterpillar to a chrysalis, a chrysalis to a butterfly, or a tadpole to a frog, there is nothing *new* in the organization; all the parts of the gnat, the butterfly, and the frog, having really existed, though not appearing to the common observer in the forms in which they are first seen. In like manner, every thing essential to the oak is found in the acorn.

It is now, however, maintained that bodies as exquisitely organized as any that we are acquainted with (for this is true of the smallest insect, as well as of the largest animal) arise, without the interposition of a creative power, from substances that have no organization at all, from mere *brute matter*—earth, water, or mucilage, in a certain degree of heat. Sometimes the term *organic particles* is made use of, as the origin of the plants and animals that are said to be produced this way; but as it is without meaning, the germs of those specific plants and animals which are said to come from them, and a great variety of these organized bodies are said to arise from the same organic particles, the case is not materially different. Still, completely organized bodies, of specific kinds, are maintained to be produced from substances that could not have any natural connexion with them, or particular relation to them. And this I assert is nothing less than the production of an effect without any adequate cause. If the organic particle, from which an oak is produced be not precisely an acorn, the production of it from any thing else is as much a miracle, and out of the course of nature, as if it had come from a bean, or a pea, or absolutely from nothing at all; and if miracles be denied, (as they are, I believe, by all the advocates for this doctrine of equivocal generation,) these plants and animals, completely organized as they are found to be, as well adopted to their destined places and uses in the general system as the largest plants and animals, have no *intelligent cause* whatever, which is unquestionably atheism. For if one part of the sys-

tem of nature does not require an intelligent cause, neither does any other part, or the whole.

As Dr. Darwin presses my observations on the *green matter*, on which I formerly made some experiments, as producing dephlogisticated air by the influence of light, into the service of his hypothesis; I have this last summer given some attention to them, and have diversified them with that view; and from these it will appear that they are far from serving his purpose; since none of this green matter, which he does not doubt to be a vegetable, though of the smallest kind, is produced in any water, though ever so proper for it, unless its surface has been more or less exposed to the atmosphere, from which, consequently, the invisible seeds of this vegetable may come.

He says (*Temple of Nature, notes p. 4.*) “not only microscopic animals appear to be produced by a spontaneous vital process, and these quickly improve by solitary generation, like the buds of trees, or like the polypus and aphid, but there is one vegetable body which appears to be produced by a spontaneous vital process, and is believed to be propagated and enlarged in so short a time by solitary generation, as to become visible to the naked eye. I mean the green vegetable matter first attended to by Dr. Priestley, and called by him *conferva fontinalis*. The proofs that this material is a vegetable are from its giving up so much oxygen when exposed to the sun shine, as it grows in water, and from its green colour.”

“D. Ingenhouz asserts that by filling a bottle with well-water, and inverting it immediately into a basin of well-water, this green vegetable is formed in great quantity; and he believes that the water itself, or some substance contained in the water, is converted into this kind of vegetation which then quickly propagates itself.”

“Mr. Girtanner asserts that this green vegetable matter is not produced by water and heat alone, but requires the sun’s light for this purpose, as he observed by many experiments, and thinks it arises from decomposing water deprived of a part of its oxygen; and he laughs at Dr. Priestley for believing that the seeds of this *conferva*, and the parents of

“ microscopic animals, exist universally in the atmosphere, and “ penetrate the sides of glass jars.” *Philosophical Magazine for May 1800.*

He further says, p. 9, “ The green vegetable matter of Dr. Priestley, which is universally produced in stagnant water, “ and the mucor, or mouldiness, which is seen on the surface “ of all putrid vegetable and animal matter, have probably “ no parents, but a spontaneous origin from the congress of “ the decomposing organic articles, and afterwards propagate “ themselves.”

Let us now compare *this* language with that of *nature* in my experiments. On the first of July I placed in the open air several vessels containing pump-water, two of them covered with olive oil, one in a phial with a ground glass stopper, one with a loose tin cover, and the rest with the surface of the water exposed to the atmosphere; and having found (as may be seen in the account of my former experiments on this green matter) that it was produced with the greatest facility, and in the greatest abundance, when a small quantity of vegetable matter, especially thin slices of raw potatoes, was put into the water, I put equal quantities, viz. twenty grains of potatoe, into each of the larger vessels and ten into each of the smaller. Into two very large decanters, the mouths of which were narrow, I put fifty grains of the same, one of them having oil on its surface, and the other none. At the same time having filled a large phial with the same water, I inverted it in a vessel of mercury.

In about a week the wide mouthed open vessel began to have green matter, and the large decanter with the narrow mouth had the same appearance in three weeks. On the first of August the vessel which had a loose tin cover, coming about half an inch below its edge, had a slight tinge of green, and on the first of September the phial with the ground glass stopper (but which, appeared by some of the water escaping, not to fit exactly) began to have green matter. But none of the vessels that were covered with oil, or that which had its mouth inverted in mercury, had any green matter at all on the 12th of September; when, having waited as I thought long enough, I put an end to the experiment.

Here we see that the wider was the mouth of the vessel, the sooner did the green matter appear in it; but that in time the germ (or whatever it may be called that produced it) found its way through the smallest apertures, and were ascended into the vessel with the tin cover before it could descend into it; but that when all access to the water was precluded by a covering of oil, or a quantity of mercury, no green matter was produced. These experiments, therefore, are far from favouring the doctrine of spontaneous generation, but are perfectly agreeable to the supposition that the seeds of this small vegetable float in the air, and insinuate themselves into water of a kind proper for their growth, through the smallest apertures.

Among the *experimental facts*, as Dr. Darwin calls them, in the support of his hypothesis, he says, p. 3. "that one or more of four persons, whom he names, put some boiling veal broth into a phial previously heated in the fire, and sealing it up hermetically, or with wax, observed it to be replete with animalcules in three or four days." But he should have said which of these four persons made the experiment, and have referred to the passage in their writings in which it is mentioned. Otherwise no judgment can be formed of its accuracy. And why did not the Doctor repeat the experiment himself, since it is so easily done? Besides, we know that even the heat of boiling water will not destroy some kinds of insects, and probably much less the eggs, or embryo's, of them.

He adds (*ib.*) that "to suppose the eggs of former microscopic animals to float in the atmosphere, and pass through the sealed glass phial, is so contrary to apparent nature, as to be totally incredible." But who does, or would suppose this. That various animalcules, as well as the seeds of various plants, invisible to us, *do* float in the atmosphere, is unquestionable; but that they pass through glass I never heard before, though in a preceding paragraph it is ascribed to myself. He adds, "as the latter are viviparous, it is equally absurd to suppose that their parents float universally in the atmosphere, to lay their young in paste, or vinegar." To me, however,

this does not appear to be at all *impossible* ; and it is observation of *facts*, and not *conjecture*, that must determine the question of *probability*.

“ Some other *fungi*” he says p. 9. “ as those growing in close wine vaults, or others which arise from decaying trees, or rotten timber, may perhaps be owing to a similar spontaneous production, and not previously exist as perfect organic beings in the juices of the wood, as some have supposed. In the same manner it would seem that the common esculent mushroom is produced from horse dung at any time, and in any place, as is the common practice of many gardeners.” This requires no particular answer. Decaying trees &c. may afford a proper *nidus* for the seeds of vegetables that are invisible to us; and that any of them previously exist in the juices of the tree, was I believe, never supposed. The horse dung also may afford a proper *nidus* for the seeds of the mushroom. Besides these are only random observations, and the facts have never been investigated in an accurate philosophical manner.

It is said by many, that the different kinds of worms which are found in animal bodies have their origin there, and from no worms of the same kinds, but from the unorganized matter of which our food consists. But according to later observations, most of these very worms have been found *out* of the body, and therefore there is nothing improbable in the supposition of the seminal matter from which they came having been conveyed into the body in the food, &c. and if some of them have been found out of the body, the rest may in time be found out of it also. It is, besides, unworthy of philosophers to draw important conclusions from mere ignorance.

Having recited these facts, and *supposed facts*, I shall consider distinctly all that Dr. Darwin has advanced by way of *argument* in defence of the system that he has espoused.

He supposes, what no person will deny, that “ dead organic matter, or that which had contributed to the growth of vegetable and animal bodies, may by chemical attractions, in the organs of plants and animals, contribute to the nourishment of other plants and animals.” But he adds, p. 6.

“ the same particles of organic matter may form spontaneous
 “ microscopic animals, or microscopic vegetables, by chemi-
 “ cal dissolutions, and new combinations of organic matter,
 “ in watery fluids with sufficient moisture.”

But these microscopic vegetables and animals, there is every reason to think, have as complete and exquisite an organic structure as the larger plants and animals, and have as evident marks of design in their organization, and therefore could not have been formed by any decomposition or composition of such dead matter, whether called *organic* or not, without the interposition of an intelligent author. Besides, these microscopic vegetables and animals are infinitely various, and therefore could never arise from the same dead materials, in the same circumstances, by the mere application of warmth and moisture. Each of these vegetables and animals must, according to the analogy of nature, have proceeded from an organized germ, containing all the necessary parts of the future plant or animal, as well as the largest trees and animals, though their minuteness elude our search, and though the manner in which their seeds or germs are conveyed from place to place be unknown to us. But the attention that is given to this subject by ingenious naturalists is continually discovering a greater analogy between these microscopic vegetables, and animals and those of the largest kinds. This argument from the production of minute plants and animals has no force but from our ignorance.

“ It is as difficult,” he says, p. 7. “ to understand the at-
 “ traction of the parts of coutchouk, and other kinds of at-
 “ traction, as the spontaneous production of a fibre from de-
 “ composing animal or vegetable substances, which contracts
 “ in a similar manner, and this constitutes the primordia of
 “ life.” But admitting that the power by which a fibre contracts to be not more difficult to comprehend than other contractions, and that fibres are the primordia of life, whence comes the regular arrangement of these fibres, and the various system of vessels formed by them, for the purposes of nutrition, the propagation of the species, &c. in the complex structure of these minute animals. There is nothing like that in the coutchouk, or any other substance that is not an animal.

Microscopic vegetables and animals remaining without any visible sign of life months and years is no proof that they were capable of deriving their origin from dead unorganized matter. While their organization is not destroyed, the motions which indicate life may be restored by proper degrees of heat and moisture; but this is not materially different from the case of frogs and other animals, which discover no sign of life, a great part of the winter, and revive with the warmth of spring.

That any thing composing an animal or vegetable should, after affording nutriment to other animals, attain some kind of organization, or even vitality, may be admitted; because the digestive powers of animals may not be able to destroy their organization, or vitality. But if it remain uninjured, and be afterwards revived, it cannot be any thing besides the very same organization that it had before. So birds feed upon seeds, which yet retain so much of their organization, and life, as to be able to produce the plants from which they came, but never any of a different kind. Beyond this no analogy in nature can carry us.

“ These microscopic organic bodies,” he says, p. 8. “ are multiplied and enlarged by solitary re-production, without sexual intercourse, till they acquire greater perfection, or new properties. Liewenhock observed in rain-water which had stood a few days, the smallest scarcely visible animalcules and in a few days more he observed others eight times as large.” But this proves nothing more than an increase in bulk, and no change of a small animal into a larger of a different kind, which the argument requires. If it was the same animal that assumed a new form, in a more advanced state, it is no more than the case of a tadpole and a frog, or a caterpillar and butterfly. That several insects are multiplied without sexual intercourse is no proof of spontaneous generation. Plants are several ways produced without seeds; and according to Dr. Darwin’s observations, this mode of animal re-production has its limits. For that after a certain number of such generations the last discover the properties of *sex*, and then produce others by sexual intercourse, so that it is probable, that if at

that time they could be kept from sexual intercourse the reproduction would cease.

Dr. Darwin, and all other advocates for spontaneous generation, speaks of some animals as *simple* and others as *complete*, some as *imperfect* and others as *perfect*; whereas, as far as we can discover, all animals, even the most minute that have been examined, appear to be as perfect, and to have a structure as wonderfully complicated, as the largest, though on account of their minuteness, we cannot dissect them to so much advantage. Their organs are equally adapted to their situations and occasions; and what is more, they have as great a degree of *intelligence* (which they discover by the methods of seeking their food, avoiding, or contending with their enemies) as the largest animals: besides, it is never pretended that any large species of animals, though called imperfect, as crabs and oysters, &c. are ever produced by spontaneous generation.

The larger kinds of the more perfect animals Dr. Darwin does not pretend to have ever been "produced immediately in this mode of spontaneous generation;" but he supposes, what is even more improbable, viz. that "vegetables and animals improve by re-production; so that spontaneous vitality (p. 1.) is only to be looked for in the simplest organic beings, as in the smallest microscopic animalcules, which perpetually perhaps however enlarge themselves by re-production; and that the larger and more complicated animals have acquired their present perfection by successive generations, during an uncounted series of ages."

By this he must have meant to insinuate, for it is not clearly expressed (perhaps to avoid the ridicule of it) that lions, horses, and others, which he considers as more complicated animals, though they are not more so than flies and other insects, may have arisen from animals of different kinds, in the lowest state of organization, in fact, that they were once nothing more than microscopic animalcules.

But this is far from being analogous to any thing that we observe in the course of nature. We see no plants or animals, though ever so simple, growing to more than a certain size, and producing their like, and never any others organized in a

different manner. Is it at all probable that lions, horses or elephants, were ever any other than they now are? Were they originally microscopic? And if they come to be what they now are by successive generations, why does not the change and improvement go on? Do we ever see any small animal become a larger of a different kind? Do any mice become rats, rats become dogs, or wolves, wasps become hornets, &c. and yet this is precisely the analogy that the hypothesis requires.

In order to obviate the prejudice against this doctrine of spontaneous production, as favouring *atheism*, Dr. Darwin says of the objectors, p. 1. "They do not recollect that
 " God created all things which exist, and that these have
 " been from the beginning in a perpetual state of improve-
 " ment, which appears from the globe itself, as well as from
 " the animals and vegetables which possess it. And lastly,
 " that there is more dignity in our idea of the Supreme
 " Author of all things, when we conceive Him to be the
 " cause of causes, than the cause simply of the events
 " which we see, if there can be any difference in infinity of
 " power."

The Supreme Being is, no doubt, the cause of all causes; but these causes have a regular connexion, which we are able to trace; and if any thing be produced in any different manner, we say it is not according to the course of nature, but a *miracle*. The world is, no doubt, in a state of improvement; but notwithstanding this, we see no change in the vegetable or animal systems, nor does the history of the most remote times favour the hypothesis. The plants and animals described in the book of Job are the same that they are now, and so are the dogs, asses, and lions &c. of Homer.

Vegetables and animals do not by any improvement, natural or artificial, change into one another, or into vegetables and animals of other species. It is, therefore, contrary to analogy, or the established course of nature, that they should do so. If miracles; which imply an omnipotent and designing power (and which to the generality of mankind are the most striking proofs of the existence of such a power, and a power distinct from the visible parts of nature, the laws of which

it counteracts) be denied, all changes that take place contrary to the observed analogy of nature must be *events without a cause*; and if one such event can take place, any others might, and consequently the whole system might have had no superior designing cause; and if there be any such thing as *atheism*, this is certainly it.

Dr. Darwin speaks of his organic particles as possessed of certain *appetencies*, or *powers of attraction*. But whence came these powers, or any others, such as those of electricity, magnetism, &c.? These powers discover as much wisdom, by their adaptation to each other, and their use in the general system, as the organic bodies which he supposes them to form; so that the supposition of these *powers*, which must have been imparted *ab extra*, only removes the difficulty he wishes to get quit of one step farther, and there it is left in as much force as ever. There are still marks of *design*, and therefore the necessity of *a designing cause*.

No. XXV.

Observations on the Discovery of Nitre, in common Salt, which had been frequently mixed with Snow, in a Letter to Dr. Wistar, from J. Priestley, L. L. D. F. R. S.

Read, December 2, 1803.

DEAR SIR,

WHEN I had the pleasure of seeing you at Northumberland, I mentioned a fact which I had just observed, but which appeared to me so extraordinary, that I wished you not to speak of it till I had more completely ascertained it. It was the conversion of a quantity of common salt into nitre. But having seen, in the last *Medical Repository*, an observation of Dr. Mitchell's, which throws some light upon it, I think it best upon the whole to acquaint experimentalists in general with all that I know of the matter; that, as the experiments must be made in the winter, they may take advantage of that which is now approaching.